Status of WU Nitride Photocathode Development

Jim Buckley and Dan Leopold
10/5/2010
Recent Measurements

• Improvements made to RHEED system
• Construction of tube sealing/transfer/QE system
• Low-temperature growth of amorphous GaN and InGaN cathodes.
  • Cathode was fabricated with increased In concentration (25%). Growth for about 3 hours, ~100 nm/hour.
• QE and electron diffraction as a function of annealing.
• Optical transmission measurements.
• Photo of lab showing recent additions
Amorphous Cathodes

- Began experimenting with a-GaN cathode produced a number of years ago for NMR materials studies.

- Restored surface, Cs-activated. Obtained QEs ~5%, encouraging further studies.

- Grew ~0.3micron, InGaN cathode with 25% Indium, looked at RHEED data and QE as a function of annealing.
RHEED Measurements

Sapphire - 70deg

Sapphire - 10deg
RHEED Measurements

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a-InGaN no anneal
RHEED Measurements

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a-InGaN 300C

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RHEED Measurements

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a-InGaN 300C

a-InGaN 390C
Increased Indium

- Increased Indium concentration to 25% - increased quantum efficiency at all wavelengths, improved QE at long wavelengths
• Measured optical absorption using a Xe-lamp, double-grating monochromometer, UDT UV-enhanced reference photodiode and Keithley electrometer. Absorption is normalized to a measurement for an identical sapphire substrate with no coating.

• Compared with crystalline or amorphous GaN, broader band-edge, more absorption at long wavelengths showing band shifting.
Conclusions

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- Amorphous cathode growth allows use of new substrates - conductive coatings on glass for HV bias.
Future Work

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• Optimize cathode structures
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- Deposit a-InGaN on ITO-coated window, apply grid electrodes, apply voltage bias and measure gain-QE product versus voltages
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• Transfer glass MCP directly coated with nitride cathode material (Fall 2011)
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• Transfer glass MCP directly coated with nitride cathode material (Fall 2011)

• Finish development of new vacuum transfer stage for hot/cold indium sealing for transfer, transmission-mode QE measurements
Growth Parameters
Device Optimization

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Characterization

- In-situ QE measurements versus wavelength (WU)
- RHEED measurements and analysis during growth (WU)
- Room-temperature optical transmission measurements (WU)
- Hall measurements of carrier densities, conductivity (ANL)
Tube Testing and Sealing

- Tube-sealing system
- Photocathode/sapphire window
- Evaporation system
- To MBE system
- Housing holder
- Linear/rotary motion probe
- Evaporation source and mask
- Translation stage for compression seal
• Develop tube sealing/transfer/testing system
Tube Testing and Sealing

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- Transmission-mode QE measurements for comparison with reflection mold measurements
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• Hot (150 C) and Cold Indium seals

• Ti evaporator for coating of window and housing in vacuum, compression of In wire in O-ring groove
Tube Testing and Sealing

- Develop tube sealing/transfer/testing system

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- Hot (150 C) and Cold Indium seals
  - Ti evaporator for coating of window and housing in vacuum, compression of In wire in O-ring groove
  - Incorporate SAES getter into housing
Push-rod Detail

- Tube housing
- Adaptor
- Docking flange
- Indium O-ring groove
- Reducing flange with HV and signal feedthroughs
Push-rod Detail

- Tube housing
- Adaptor
- Docking flange
- Indium O-ring groove
- Spring clip
- Small offset demate interface
- Reducing flange with HV and signal feedthroughs
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- Small offset demate interface
- Clip release screws

Reducing flange with HV and signal feedthroughs

Docking flange detail

Adaptor detail

LAPPD Godparent Review, Oct 5, 2010

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Push-rod Detail

- Tube housing
- Adaptor
- Docking flange
- Indium O-ring groove
- Spring clip
- Small offset demate interface
- Clip release screws
- Reducing flange with HV and signal feedthroughs
- Ceramic spacer
Push-rod Detail

- Tube housing
- Adaptor
- Docking flange
- Indium O-ring groove
- Spring clip
- Small offset demate interface
- Clip release screws
- Ceramic spacer
- Wire adaptors to match tube pin-out

- Reducing flange with HV and signal feedthroughs
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- Salary support (0.75 FTE Dan Leopold, 0.5 Grad Student)
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  - SAES getters (5m strip, ST-707-CTS-NI-8D, $130)
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  - ~150C heater (components ~$2k)
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  - Power supply (HP 6552A power supply $3.5k)
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  - Machine shop time for transfer system ($5k)
Backup Slides
Eventually we might try more advanced band-engineering to achieve solid state PM